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[54] **CATALYTIC IGNITOR FOR REGENERATIVE PROPELLANT GUN**

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[51] **Int. Cl.**[6] **F41F 1/00**

[52] **U.S. Cl.** **89/7**; 89/7

[58] **Field of Search** 89/7, 8

[56] **References Cited**

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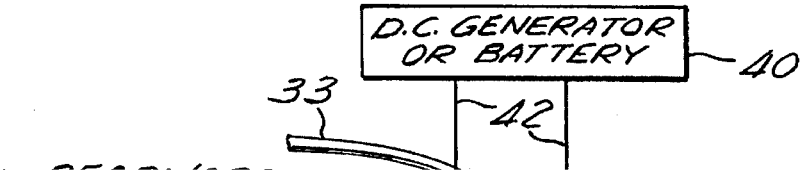
[57] **ABSTRACT**

An ignitor initiates combustion of liquid propellant in a gun by utilizing a heated catalyst onto which the liquid propellant is sprayed in a manner which mitigates the occurrence of undesirable combustion chamber oscillations. The heater heats the catalyst sufficiently to provide the activation necessary to initiate combustion of the liquid propellant sprayed thereonto. Two embodiments of the ignitor and three alternative mountings thereof within the combustion chamber are disclosed. The ignitor may also be utilized to dispose of contaminated, excess, or waste liquid propellant in a safe, controlled, simple, and reliable manner.

20 Claims, 2 Drawing Sheets



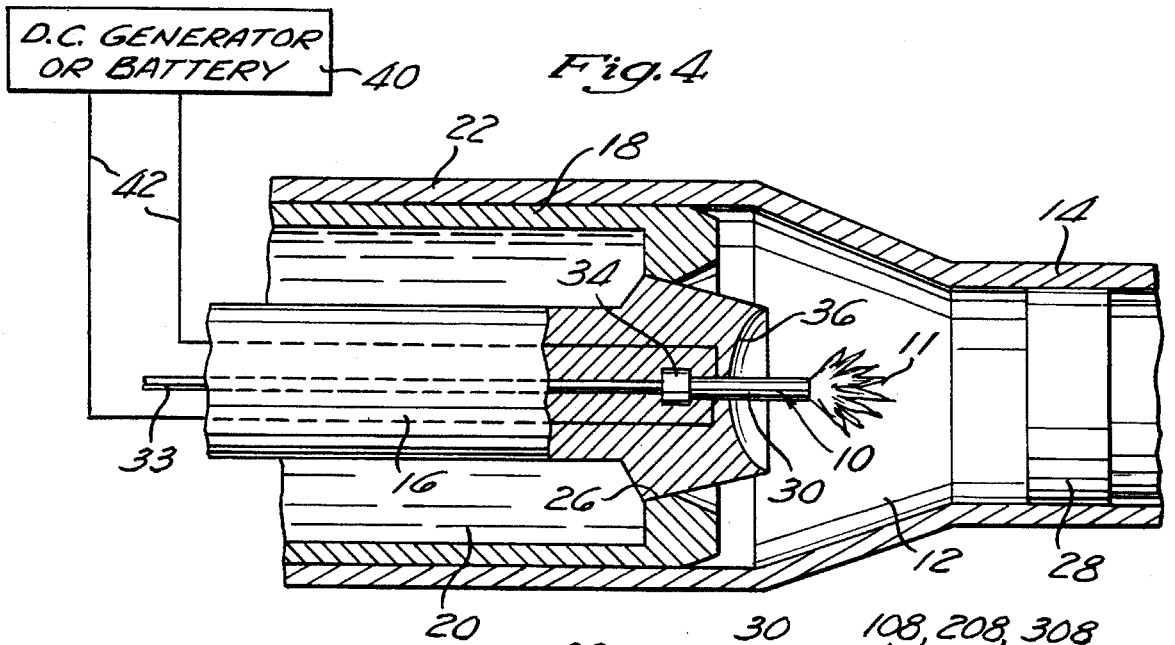


Fig. 4

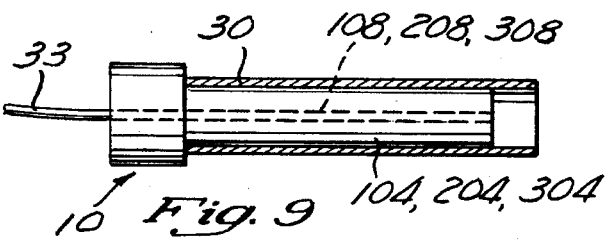


Fig. 9

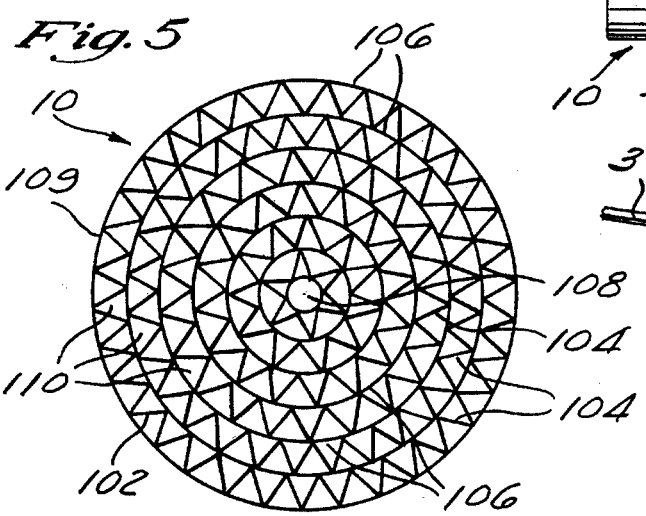


Fig. 5

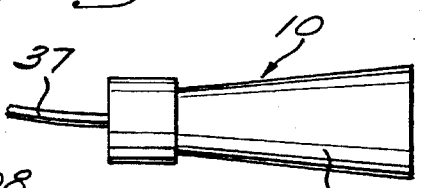


Fig. 8

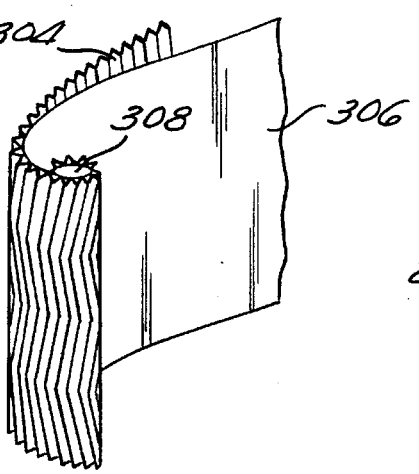


Fig. 7

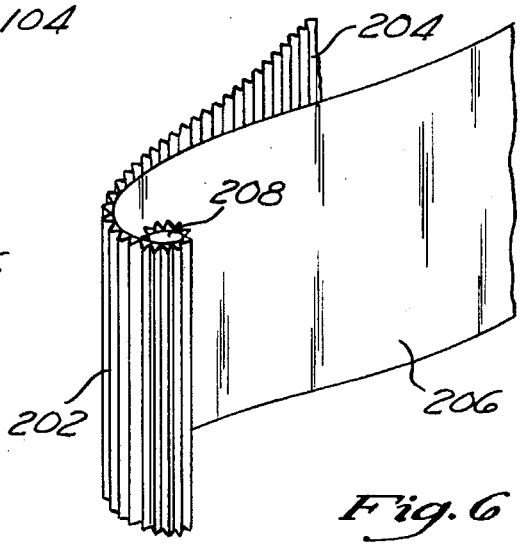


Fig. 6

CATALYTIC IGNITOR FOR REGENERATIVE PROPELLANT GUN

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract, and is subject to the provisions of Public Law 96-517 (35 U.S.C. 202) in which the contractor has elected not to retain title.

TECHNICAL FIELD

The present invention relates generally to weaponry and more particularly to an ignitor for initiating combustion of liquid propellant in a regenerative propellant gun, wherein the liquid propellant is sprayed upon, and passed through, a heated catalyst bed in a manner which facilitates smooth combustion of the liquid propellant and thus mitigates undesirable combustion chamber oscillations.

BACKGROUND ART

Regenerative propellant guns wherein a liquid propellant is pumped into a combustion chamber and ignited so as to propel a projectile from the barrel of the gun are known. Such contemporary regenerative liquid propellant guns typically comprise a variable volume combustion chamber wherein inner and outer concentric pistons cooperate to pump and meter additional liquid propellant into the combustion chamber as the combustion process proceeds. Liquid propellant disposed within a reservoir formed between the inner and outer pistons is forced out of the reservoir as the inner and outer pistons are moved in a combustion chamber volume increasing direction as a result of the combustion process.

The liquid propellant is forced through an annular opening formed between the inner and outer pistons as the inner and outer pistons travel in the combustion chamber volume increasing direction. The flow of liquid propellant from the reservoir is metered into the combustion chamber by the annular orifice whose area depends upon the relative positions of the inner and outer pistons.

The ignition of liquid propellant within contemporary regenerative liquid propellant guns is typically performed as a four step process. In the first step, a mail box or primer charge is ignited at the distal end of an ignition tube connected to the combustion chamber. In the second step, the primer charge ignites a larger intermediate quantity of liquid explosive disposed within the tube at a position closer to the combustion chamber. In the third step, the intermediate charge ignites a puddle charge disposed within the combustion chamber. In the fourth step, the puddle charge ignites the main charge so as to initiate regenerative combustion of liquid propellant sprayed from the reservoir into the combustion chamber of the gun. As such, the initiation of the main charge involves an undesirably complex and unreliable series of separate steps.

Prior to ignition of the puddle charge disposed within the combustion chamber, the inner and outer pistons are in a minimum combustion chamber volume position wherein the inner and outer pistons cooperate to close the annular orifice defined therebetween and thus prevent the flow of liquid propellant from the reservoir into the combustion chamber.

Upon ignition of the puddle charge, increased pressure within the combustion chamber urges the inner and outer pistons in a combustion chamber volume increasing direction. Typically, the inner piston, having a greater surface area

than the outer piston, is urged in the combustion chamber volume increasing direction at a slightly faster rate than the outer piston. Thus, such relative motion of the inner and outer pistons causes them to separate and open the annular orifice to the liquid petroleum reservoir. Movement of the inner and outer pistons reduces the volume of the liquid propellant reservoir, thus forcing liquid propellant from the liquid propellant reservoir into the combustion chamber at a rate determined by the movement of the inner and outer pistons and the area of the annular orifice formed therebetween. Such pumping of the liquid propellant from the reservoir into the combustion chamber by the inner and outer pistons facilitates the regenerative combustion process so as to accelerate a projectile through the barrel of the gun.

Such regenerative guns commonly utilize a liquid propellant comprising a concentrated aqueous nitrate salt solution. Such concentrated aqueous nitrate salt solutions are substantially viscous and dense. They require an elevated temperature and pressure in order to sustain continuity in the combustion reaction.

The aqueous nitrate salt solutions commonly utilized in regenerative propellant gun applications typically comprise hydroxylammonium nitrate (HAN) and triethanolammonium nitrate (TEAN). It has been suggested that combustion of the HAN and TEAN involves a first reaction wherein the decomposition of HAN releases hydroxyl radicals and heat so as to produce an increase in pressure within the combustion chamber, followed by a subsequent reaction involving the rapid chemical reaction of the TEAN.

The ignition of such premixed fuel/oxidant liquid propellants is commonly initiated in contemporary regenerative propellant guns by electrical arcs, explosives and lasers, for example, which provide the conditions necessary to sustain completion of the subsequent chemical reactions. However, the heat initially generated by such contemporary ignitors is rapidly absorbed by the water component of the aqueous nitrate salt solution, thus generating steam. A substantial quantity of the energy provided by such contemporary ignitors is thus undesirably utilized in converting the water of the aqueous nitrate salt solution into steam, thereby increasing the quantity of energy which must be provided by the ignitor in order to heat and ignite the liquid propellant.

The puddle charge utilized in contemporary regenerative guns inherently has a limited surface area available for atomization and reaction, further increasing the quantity of energy required to be provided by the ignitor. Such puddle charges of liquid propellant inherently result in slow and very directional combustion reactions.

Because the energy requirements for reliable ignition of the liquid propellant in contemporary regenerative propellant guns is substantial, the use of electrical energy, i.e., electrical arcs, lasers, etc., is not convenient for battlefield applications.

Furthermore, it is difficult to attain reliable and consistent ignition of liquid propellants in such contemporary regenerative propellant guns. Reliability and consistency of ignition of the liquid propellants used in contemporary regenerative propellant guns is reduced due to the high energy requirement for such ignition and the low surface area associated with the puddle charge used therein.

Such inconsistency in the ignition process is thought to contribute to the generation of undesirable combustion oscillations which occur as additional liquid propellant is sprayed into the combustion chamber during the regenerative process. Such combustion chamber oscillations inhibit precise control of the combustion process which is required for

liquid propellant or, alternatively may be utilized as a combined ignitor and flame holder by controlling the flow of liquid propellant therethrough.

Such a combined ignitor and flame holder may be utilized in various applications wherein it is desirable to maintain a flame at a given location. For example, U.S. Pat. No. 4,938,112 issued on Jul. 3, 1990 to Hertzberg et al. and entitled APPARATUS AND METHOD FOR THE ACCELERATION OF PROJECTILES TO HYPERVELOCITIES utilizes a flame holder to ignite gaseous propellant in a combustion chamber so as to accelerate a projectile upon which the flame holder is formed.

Those skilled in the art will appreciate that various other uses for such flame holders are likewise possible. Indeed, such a combination of ignitor and flame holder may be used in any application wherein it is desirable to maintain a flame within or proximate a device utilizing the flame. Moreover, the catalytic ignitor of the present invention may find use in various applications other than regenerative propellant guns

the presently preferred embodiments of the invention, and is not intended to represent the only forms in which the present invention may be constructed or utilized. The description sets forth the functions and sequence of steps for constructing and operating the invention in connection with the illustrated embodiments. It is to be understood, however, that the same or equivalent functions and sequences may be accomplished by different embodiments that are also intended to be encompassed within the spirit and scope of the invention.

The ignitor for initiating combustion of liquid propellant in a regenerative propellant gun according to the present invention is illustrated in FIGS. **1–9** which depict three presently preferred embodiments of the invention.

Referring now to FIGS. **1** and **2**, the ignitor **10** extends from a wall **13** of the combustion chamber **12** of a regenerative propellant gun having a barrel **14**, an inner piston **16**, an outer piston **18**, and a reservoir **20** formed intermediate the inner **16** and outer **18** pistons. The inner **16** and outer **18**

surface of a substrate. The substrate preferably comprises corrugated material **102** formed in a plurality of concentric tubular layers **104** and separated by non-corrugated layers **106**. Both the corrugated layers **104** and non-corrugated layers **106** preferably comprise a substrate having a catalyst formed thereon so as to maximize catalytic surface area. A center or first electrode **108** is formed along the longitudinal axis of the tubular ignitor **10** and the outermost non-corrugated layer **109** forms an outer or second electrode. Thus, a plurality of individual passageways **110** through which liquid propellant is sprayed are defined by the corrugated **102** and non-corrugated **106** substrates.

Referring now to FIG. **6**, in a second embodiment of the ignitor **10** for initiating combustion of liquid propellant of the present invention, the corrugated substrate **204** is spirally rolled to form a tube. As in the first embodiment of the ignitor, the adjacent layers of corrugated substrate **204** may optionally be separated by a non-corrugated layer of sub-

increase the active surface area of the subsequently applied catalyst. The alumina wash coat is substantially rough and porous as compared to the comparatively smooth surface of the substrate. The catalyst thus impregnates the wash coat.

Further, in each preferred embodiment of the present invention, apertures, e.g., holes, slots, slits, etc., are optionally formed in the corrugated members **104**, **204**, **304** and/or the non-corrugated members **106**, **206**, **306** so as to facilitate flow of the effluent laterally between passageways **110**.

The catalyst is preferably comprised of a transition metal or alloy, preferably a noble metal such as platinum, palladium, rhodium, iridium, ruthenium, or osmium. Those skilled in the art will recognize that various metals and/or alloys thereof are suitable for use as such a catalyst.

Having thus described the structure of the ignitor for initiating combustion of liquid propellant of the present invention, a brief description of the operation thereof may be useful. The substrate of the ignitor **10**, comprising both the

modifications and additions may be made to such embodiments without departing from the spirit and scope of the invention. For example, the particular configuration of the substrate may comprise structures other than the corrugated and non-corrugated concentric rings or spiral, as described and illustrated. The substrate may comprise a plurality of elongate tubular members positioned together in a bundle, through which the liquid propellant is sprayed. Additionally, various other means of providing electrical interconnection to the substrate to facilitate heating thereof are similarly contemplated. Thus, these and other modifications and additions may be obvious to those skilled in the art and may be implemented to adapt the present invention for use in a variety of different applications.

We claim:

1. A liquid propellant gun for firing a projectile, the gun comprising:

(a) a barrel;

(b) a combustion chamber formed at one end of said barrel such that combustion of liquid propellant therein effects movement of the projectile through said barrel;

(c) a sprayer for spraying liquid propellant into said

9. The gun as recited in claim **7** wherein said corrugated material comprises corrugations configured as chevrons.

10. The gun as recited in claim **1** wherein said catalyst comprises a metal selected from the group consisting of:

(a) platinum;

(b) palladium;

(c) rhodium;

(d) iridium;

(e) ruthenium; and

(f) osmium.

11. The gun as recited in claim **1** wherein said catalyst is formed in a tubular configuration and the liquid propellant flows therethrough.

12. The gun as recited in claim **1** wherein said catalyst is formed in a conical configuration such that the liquid propellant expands as it flows therethrough.

13. The liquid propellant gun as recited in claim **1** wherein the ignitor is disposed upon the stationary wall of the combustion chamber.

14. The liquid propellant gun as recited in claim **1** wherein the ignitor is disposed upon said inner piston.

15. The liquid propellant gun as recited in claim **1** wherein